Industrial recycling networks as an entrance into circular economy

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Sustainable economy and circular economy

The term sustainability in principle is very old (see for instance Beckmann 1757). But not until the so-called Brundtland report (World commission 1987) the terms „sustainability“ and „sustainable development“ became known and part of public consciousness. In the Brundtland report sustainable development is defined as follows: „ ....it meets the needs of the present without compromising the ability of future generations to meet their own needs“ (World commission 1987, p. 8). Thus sustainability is also a means to bridge the generation gap.

In the end satisfaction of needs fall back upon natural stocks. Therefore sustainable development means a prudent attitude with natural resources. But there exists an important difference: Natural resources may originate from renewable raw materials, e. g. plants, animals, oxygen. These are preserved as long as we only use the increase and maintain at least a minimum reproductive stock.

If the conditions mentioned above are met, the renewable resources will remain all the time and sustainable development will be really achieved.

Irreproducible raw materials, e. g. metals or crude oil are only available in restricted quantities because they – at most – could be increased only in periods of time that are irrelevant for human planning horizons, e. g. crude oil. Taking such materials out of nature therefore means their definite economic loss.

It is true that in accordance with the law of preservation of materials, matter cannot be destroyed, but only be shaped or changed. But by processing materials they will be distributed physically so that they will not exist in high concentration any longer. Its regaining for production and consumption demands technological and organisational efforts and is often technologically impossible or simply uneconomic. So, Stumm and Davis showed that regaining copper from chemical compounds and scattered materials even in case of infinite consumption of energy will only reach a share of about 70 % (Stumm/Davis 1991). Therefore - here and in other cases too - recycling is not the solution of the shortage of stocks. Only with a – not realistic – recycling potential of 100 % recycling could guarantee sustainability with not reproducible materials.

In this situation we could think of the possibilities to substitute a material already used. But if the replacing material isn’t a reproducible one, the problem of availability of the demanded function will appear later again, and the problem of finite stocks will catch us up. So, sustainable development is finally restricted to reproducible materials, and we are referred again to natural processes that work with growing materials.

This indication brings us immediately to the subject of circular economy (cf. in detail Sterr 2003). The model for circular economy is nature. It carries on circular economy in so-called ecological cycles (ecocycles) , that are living communities in their habitats. Here a regulated matter and energy circle does exist which sets up, transforms and decomposes energy containing matters within local limited matter quantities, but with the supply of sun energy. Nature has worked for billions of years with a constant stock of matter and influx of sun energy, and waste doesn't arise here at least in the long run.

Meanwhile the principles of circular economy are demanded for human economy, too. The German Council of experts of environmental problems stated in 1994 already: In order to guarantee a safe future for the environment it (human economy, H. S.) must be circular so that the processes of production are integrated in natural circles from the very beginning, and: "a not ecologically compatible manner of economy is directly opposite its own reason, because it destroys something human economy lives on" (Rat 1994, p. 9 f.). Considering this council's opinion we can only call progress what corresponds to the conditions of nature (Rat 1994, p. 11).

This claim means a thorough variation of human economy or, as H. E. Daly demands: We need development (i. e. qualitative change) rather than growth (i. e. quantitative expansion) (Daly 1996, p. 1), an opinion that could already be found in Schumpeter's theory of economic development from 1911.

Thus it is consistent for Germany to introduce a law of circular economy (Kreislaufwirtschafts-/Abfallgesetz; (circular economy/waste law) (Kreislaufwirtschafts-/Abfallgesetz vom 27. 9. 1994), that considers the ideas of nature at least partly.

Insofar circular economy is orientated to natural processes and nature is orientated to sustainability, circular economy is at the same time obviously sustainable economy.

Before we are able to analyse these connections in detail we must consider circular economy and sustainable economy in a more extensive way.

Our previous analysis and the so-called Brundtland report emphasise only certain economic functions of environment, e. g. the delivery of natural resources. This view is orientated to the input of production.

But sustainable development also means the second economic function of the environment, namely the reception and, as far as possible, the regeneration of emitted materials. Therefore sustainable development also includes maintaining the possibilities of nature to receive emitted residues and to regenerate them to a certain degree, so that a sufficient quality of the environment remains. This aspect is orientated to the output of production.

The problem's output orientated part meanwhile seems to possess higher importance. In 1972 Meadows a. o. reported of the scarce natural resources and their imminent exhaustion (Meadows a. o. 1972). On the other hand the authors dealt with the limits of admission of wastes into nature in 1992 (Meadows a. o. 1992).

If such limits exist, circle economy and sustainability can't be mere add-ons to the old economic theory. Rather they must be integrated into the theory, and circle economy and sustainability must be concepts for the practice of industrial production.

Circle economy and Sustainability as concepts for the economics of production

What can we do to realise the basic idea of sustainable development in practice, i. e. to preserve the availability of natural stocks and the capability and possibility for the regeneration of nature? I shall concentrate on environmental hazards *by producers*, because these are crucial for burdening the environment by the input and output of human activities.

Within the theory of managerial economics of the German speaking countries this problem was not a subject of discussion until about 1988. This fact is not quite comprehensible for two reasons:

1. As known, production is the essential reason of environmental burden by taking resources from natural stocks and by emitting residues. Consumption contributes to this burden, too. But the design of the products by industrial R & D also determines the environmental possibilities that remain for the user of a product.
   Environmental burdening by residues is tremendous because nature is not prepared for decomposing many kinds of residues: "Man synthesised three or four millions of new compounds that didn't exist before and gave them away into environment. This concerns millions of tons of not natural materials for which a recycling in nature is not provided (Zwilling 1993, p. 29).
2. Already in 1955 Paul Riebel laid down the fundamental principles for an economic discussion of environmental burden in his book "Kuppelproduktion" (Joint production) (Riebel 1955). But for a long time his subject was thought only a subsidiary in managerial economics instead of a rule that has no exceptions.

Managerial economics needed a long time to reduce its deficiency of environmental problems. So, the traditional production theory worked only with "goods" in input and output. Residues (in principle "bads") that were produced as an undesired output (with negative value) or are recycled as a desired input, for instance to gain energy for cement production (with positive value) didn't exist in this production theory. Not until 1992 this terminology was completed by Dyckhoff (1992). But then – in 1994 - a book about production theory was published and we can find the term "undesired good" for waste, which is an obvious terminological contradiction.

In connection with production processes the traditional production theory lacks technological foundation regarding environmental economy. In a scientific sense production means remodelling or transforming matter and energy, and this occurs by using energy and with the aid of technical process conditions.

Therefore the production theory in German speaking countries knew only physical power used by machines or other technical facilities. Other important process conditions, namely pressure, temperature, concentration, working with catalysts were unknown and therefore complete industries remained unnoticed. Here, the knowledge of environmental problems gave an important impulse.

As already known, ecological damage results especially from production, and can be influenced by controlling technical process conditions. On the other hand these process conditions open the access to the following question: What can managerial economics do to integrate sustainable development in its theory and use it in practice?

For managerial economics we may recommend the use of environmental instruments according to plan. Here, above all, the product design and the arrangement of technical processes should be focussed because their influence on the input and output of production is decisive for the quality and quantity of environmental burden, too.

Concerning the input of production the interest in renewable materials cannot be neglected, even in the automobile industry. Examples are: fibres of flax as a compound for brake coatings, tubes in brake and fuel systems produced by means of polyamides from castor-oil, headrests and driver-seats from coconuts (Frey 1994). These contributions to sustainable development are also considerably more economical than former solutions.

Relating to outputs more restrictions of environmental policy bring more environmental protections. Reductions of emissions by qualitative variations of products and processes relieve producers of such restrictions and exempt them from waste management costs.

The desire to give away produced wastes permanently and reliably to other users strengthens the tendency to offer residues as cleanly as possible. So, in view of the possibility to substitute these processed wastes with primary materials the former residuals could be transferred to the sphere of goods.

At least in the long run an environment-friendly behaviour rule is complementary with economic goals. So - already in 1984 - ecology was defined as "long-term economy" (BMI 1984, p. 88). In this respect sustainability is an actual concept for production economy, too. With the spread short-run view the economic advantages of sustainability couldn't be visible and sustainability seems to be an economically worse alternative.

A long-range view in the interest of sustainability however leads again to the question of product design. For a long time we have been presented the idea of avoiding the property of long-lasting goods in future and of leasing them only (Stahel 1997). Then producers of new products must take care of the refuse disposal of their own products. This fact will cause them to develop products in view of sustainability. So, compound products for instance will be easily stripped down and their components and materials will be separated for reusing.

The possibility of doing sustainable development/circle economy is often not given at an isolated enterprise but demands networking. Meadows a. o. name "network structures" under the conditions of a sustainable society, i. e. a society with a sustainable behaviour (Meadows a. o. 1992, p. 267, 270 ff).

A network of several enterprises, especially producing enterprises, with the intention of using residuals within this network mutually may be called "recycling network". Here, nature is the model again (see Strebel 2001).

So, nature also provides a pattern for industrial recycling networks and for the circular economy realised within them. Recycling networks are regional co-operations of producing firms in the interest of the mutual use of residues. The technical and economic function of a recycling network is the planned delivery and reception of wastes from production and consumption within the system. So, important quantities of waste remain as a secondary material stock within the recycling network and are not disposed of into the so-called environmental media of air, water and soil.

The members of the recycling network will expect economic advantages from the networking in addition to its ecological effects. The deliverer of waste is likely to get some revenues; in any case he will avoid costs of alternative waste management. The user of deliverers' residues will gain the advantage of lower material costs. By using old materials, he will often reach lower energy costs as additional improvements.

Meanwhile these recycling networks seem to be a good solution for the growing waste problems. But they remain behind in comparison with natural processes. In contrast to human actions, natural processes are the best solutions technologically and economically. So, nature proved to be not only being an excellent engineer but a good economist, too (Augros/Stanciu 1991, S. 187 ff.)

The pattern of the recycling network in industry is the so-called Industrial Symbiosis of Kalundborg (Denmark), which started in about 1972 and was presented in 1992 at the Environmental conference of Rio de Janeiro. The Industrial Symbiosis of Kalundborg has achieved important savings in inputs and significant reductions of emissions. Within one year the industrial symbiosis has realised reductions of inputs of 20 000 t of mineral oil, of 30 000 t of coal, of 130 000 t of gypsum, and of 600 000 t of water. In this connection it is of some interest that the scarcity of water in the region of Kalundborg was an important incentive to build the Industrial Symbiosis. The reductions of output were 200 000 t of CO_2 and 100 t of SO_2 (cf. Christensen 1998)

Meanwhile the start of similar networks could be realised in several countries. Approaches of this type were developed in California under the name Eco-Industrial Parks (Lowe 1998). In Europe we have got recycling networks in Austria (Posch u. a. 1998), Finland (Korhonen 2000), Germany (Hasler/Hildebrandt/Nüske 1998, Altenburg 2000, Sterr 2003), the Netherlands (Konz/van den Thillart 2002), Norway (Thoreson 2001), Even in developing countries like India and Indonesia recycling networks were developed (v. Hauff/Wilderer 2001).

In 1996 a recycling network in upper Styria was founded and is still in operation. 1996 we could identify used matter fluxes of wastes of nearly 1,5 Mio t from recycling network Styria. We found about 330 000 t of waste not yet used at that time that were suitable for economic utilisation, and until now it has been possible to reuse a part of these residues, e. g. granite wastes and dry colour wastes (cf. Strebel 2002, p.119f).

The problem of networking leads to the question of whether a circular economy is also a sustainable economy, and therefore to what extent recycling networks are in the interest of sustainable development (Strebel 2001). We remember that the so-called Brundtland Report states that every generation must preserve resources for future generations to some extent. The following concept is more precise: of every resource some stock must remain that delivers constant quantities of this resource for all the time. Here, the formulations of the Austrian forest law is really classic. It says in § 12: "...in using the forest it should be provided that exploitations .... will remain for the following generations". Meanwhile under the principles of sustainable development the forest economy is also the focus of the Pan European Forest Certification (PEFC) (see PEFC 1999).

This concept is also needed in biologically oriented models for reproducible stores like wood or fish (Perman/Yue/McGilvray 1999, p. 60). From the presented concepts of sustainable development (see Perman/Yue/McGilvray 1999, p. 56 ff) only this biological oriented one refers to nature and only for this concept the following sentence is valid: "Progress is only what is supported by the conditions of nature" (Rat 1994, p. 11). In the interest of realising this concept human behaviour must be altered in principle: " ....we must find the moral courage and political will to direct our personal and collective energy toward living within the constraints defined by ecosystem sustainability and not by political/economic desires" (Maser 1997, p. 15).

For matters such as ores, we just have the physical law of preservation (cf. p. 1). But in spite of this, the economic availability will be lost as a consequence of material entropy (cf. Georgescu-Roegen 1971) " ....after being used in production and consumption processes, these materials are discharged into the ecological cycles, as is the case with metallic compounds, fumes and synthetics ... The result is the disruption and, at worst, the destruction of ecological cycles. The industrial revolution thus marks the transition from a more or less closed system of production and consumption to an open economic system, characterised by an increasing use of natural resources with stock character" (Dietz/v. d. Straaten 1992, p. 26).Therefore every incident of consumption of such resources is a step to exhaustion as we don't have any alchemists. Sustainable development is impossible without reproducible matter.

With not reproducible matters we can only make the attempt to slow down the process of using them up. Such a result could be called "restricted" sustainability in the following text. To what extent will it be successful and how far could recycling networks help in this attempt?

Restricted sustainability demands that we deal economically with and recycle formerly used matter. Economising on natural resources includes the prolongation of product's economic lives. Extending the economic life of a product means delaying production of replacements and the refuse disposal of the replaced product. So the environment is not so often used as a supplier of resources and as a receiver of waste. But extending the product's life time may be like a sword that cuts both ways. A new product technology is often better for the environment than the old one. Remember for example the technical data of consumption and emissions of old and new cars.

In principle, the problem of sustainability does not concern the availability of a matter but relates to the need of functions delivered by this matter within a product (Knight 1921). In an economic view, therefore, sustainability does not mean the eternal existence of certain materials. The problem is namely the satisfaction of certain needs, that is the fulfilment of particular functions by using a product or a process suitably. If R & D finds a substitute for a material with lower ecological scarcity, that is in a higher stock in relation to a certain demand (Müller-Wenk 1991; critically Fritsch 1990, p. 108) or can even be reproduced, particular functions could be fulfilled by material substitutes. An instance is the substitution of copper by glass fibre in data transfer (cf. Fritsch 1990, p. 109) Both materials are not reproducible, but glass will last much longer.

By such substitutes we can use the wanted product function for a longer time than by using the material with higher scarcity. The renunciation of the original material doesn't mean the renunciation of sustainability either.

Therefore - in case of restricted sustainability - we must also see the possibilities to substitute matters of high ecological scarcity by matters of lower ecological scarcity.

If we do not see the environment in its function as a deliverer of matter but in its function as a receiver of wastes the claim is in analogy to the content of certain wood laws: In time nature may be polluted only by a degree of pollution that is capable of being processed during this time (Pearce/Turner 1990, p. 40). In view of sustainable development the emission of waste into nature is forbidden in so far as residues cannot be processed naturally or artificially.

Restricted sustainability may be pursued by several activities with inputs: Using ecologically scarce matters economically, processing of residues by following procedures or changing residues into other sorts of matters that are not so harmful, recycling, substituting ecologically scarce matters by matters of lower ecological scarcity or reducing the emission of residues to the environment.

The question remains to what extent industrial recycling networks can support these activities and thus may be considered instrumental to sustainable development.

The desire to economise on scarce matters is a fundamental principle of economy, and it is complementary to sustainable development, particularly in connection with irreproducible matter. In recycling networks with detailed and known matter and energy balances, we must expect more incentives for using residues than within an enterprise operating without such information.

By mutual recycling activities in recycling networks residues are withheld from the environment, and this corresponds to sustainable development. In this respect, recycling networks are even instruments of sustainability. You may remember the Industrial Symbiosis Kalundborg.

Producing enterprises and recycling networks, too, are not isolated institutions but they are embedded in communities. So, sustainable development is also founded on some involvement and behaviour of all partners within specified communities. In the context of sustainability, these are called sustainable communities, and they must be developed just like recycling networks. “Communities in the context of sustainability .... are a group of people with similar interests living under and exerting some influence over the same government in a shared locality” (Maser 1997, p. 99).

A sustainable community and its development are also the framework within which industrial recycling networks exist and grow. J. Christensen from the Industrial Symbiosis Kalundborg said: “We talk of a “regional” symbiosis where we are working together in many other relations (culture, municipal administration, instruction, social relations a. s. o.)” (Christensen 1998, S. 328).

So, the idea of an industrial recycling network is an unavoidable element of sustainable development and of its integration of industry into a circular economy. This is emphasised by B. Fritsch (Fritsch 1990, p. 190 f.): “If we succeed in keeping under control all matter flows, so that the environment is not dissipated, we may have economic growth in future without depleting the environment”. This is a convincing social and economic argument for establishing industrial recycling networks but also a long way.

Possibilities and incentives for circle economy and sustainable development

This chapter deals at first with the individual enterprise, because within this the approaches for the concepts mentioned must begin.

It’s true that sustainable development is a cross-section task. Nevertheless the start to sustainable development can be shown with problems assigned to special entrepreneurial departments. Here R & D, production and disposal are of great importance.

Development as the final part of R & D in the case of technical success often leads to innovations. For this, in case of a product innovation we need a product design as a result of development that is the prototype of the future production. The product design contains product technologies that enable the product to fulfil special functions when being used.

If we in this regard consider aspects of sustainable development some cost reductions may follow. Some examples were mentioned above. The classical example of the clipping problem is part of these questions. In this case energy matter and energy streams will be reduced by reducing the consumption of material and energy which is a central request of sustainable development.

Sustainable development by the reduction of material flows is also linked with processes of the chemical conversion of materials. Finally this results in the reduction of waste quantities and emissions (Schulze 1987, Christ 1995). The idea of sustainable development is here very distinctly orientated in the environment’s function as a medium of waste admission.

The decision scopes in production are determined – and this means *reduced* – by the results of development, namely the product and process innovations.

A certain influence exists with regard to process conditions as far as they are not determined by technical reasons like the strength of the electrical current in case of electrolysis. The energy consumption is influenced by decisions about process conditions, too.

In case of chemical conversion process conditions determine the qualitative and quantitative aspects of the combination of joint products. This may have some influence on the following material and energy streams in connection with procedures to separate, process and dispose of certain residues.

A circle economy by recycling residuals is possibly distributed by soiling. "...the material circle will be easily a distributor of pollutants within the productive system, for instance drugs for animals in the urine, dioxin in fodder, PCB in waste oil. The distribution of pollutants is a great danger for artificial material circles and for the use of products" (Schenkel 2000, p. 24).

Within technical processes malfunctions and rejects lead to undesired and in part to not awaited residues. Therefore the avoidance of malfunctions and rejects help for reductions of material streams and in consequence to sustainable development. It is consequent that in auditing under EMAS decree the analyses of the site's danger of malfunctions should be considered, too (Vorbach 2000, p. 41f.).

Residues will already arise during R & D, in production, in distribution and by using processes and products. These not desired effects (evils) may be explained as materials and energy which leave the circulation of goods and need a certain processing to make them again (perhaps) to goods.

Successful recycling begins with noticing, analysing, separating and storing residues and will be finished by introducing them into the selected sink. These events may happen within the own enterprise or among co-operating partners, who use these residuals productively.

It is the interest of sustainable development to find partners who are ready in the long run and on the way of co-operation to take off certain residues from certain industrial deliverers. For reaching this result the owner of residues must arouse an economic interest in these matters, perhaps as a substitute for primary material. This means fulfilment of qualitative minimum requirements by the residues but often only gaining the insight that hitherto demanded claims to the quality of input materials have been exaggerated.

Residues that cannot be recycled or converted finally must be emitted with legal restrictions into environmental media. Therefore it is in the interest of environmental protection and sustainable development to already control the arising of residues in qualitative and quantitative respect to avoid also legal problems with emissions. Here, we must consider that all emission limits are conventions and compromises and cannot be understood just like those in agreement to the standards of sustainable development.

The appearance of a special polluter by malfunctions can only be avoided if this substance cannot arise technically in the available process. This may be an incentive to a suitable choice of processes and process conditions that again may serve sustainable development.

Economic calculi for sustainable development

Sustainable development takes care of future generations. But the economic calculi are orientated completely to presence. If decisions of today are to consider the interests of future generations, we must adapt the usable long-term decision calculi.

At first this concerns decisions of enterprises but is a problem of public investments, too. So the German law demands for public investments "of considerable financial importance" (§ 6 Bundes-Haushaltsordnung (BHO); i. e. public budget rule) the use of benefit-cost examinations. It is true that the benefit-cost examination which is demanded for public investments is broader than the known benefit-cost-analysis. But the quite similar benefit-cost-analysis is a good basis for the examination of this approach.

Formally, the benefit-cost-analysis is the so-called net present value method of the entrepreneurial investment calculation. A judged alternative is characterised by its payments and from them the net present value is calculated as follows:

$$C_0 = \sum R_t q^{-t} \ (t = 0 (1) n)$$

The net present value shows – under certain premises – a satisfying project if $C_0 > 0$. This means namely that with this project the total investment sum is paid for itself until the end of duration and (at a minimum) the demanded interest rate is reached.

The net present value is calculated by discounting future revenues of the project. The later the revenue will flow in future, the lower the contribution to (today's) net present value will be because the discounting factor will be reduced with growing difference to the beginning of the investment. Suppose a revenue of 100 € in 2103. With an interest rate of 5 % (and a duration of this project of 100 years) the present value of the revenue is 1 % of its future time value, so 1 €. This means in fact that just late effects of actual decisions are practically not expressed within the calculated result and that the interests of future generations – by calculi –in general cannot have any influence on the results of today's decisions. By Turner/Pearce and Bateman this effect is called very vivid "tyranny of discounting" (Turner a. o. 1993, p. 102 f).

Another author (Betge 1988) rejects discounting environmental damages to present. But this argument is vulnerable because time values of different times must not be compared.

A formal correct method recommends not to use actual capital values but to work with future end values. But this method can only *reduce* the mentioned set of difficulties (Rückle 1998, p. 57).

These indications also fit with better information about future environmental conditions. So, the creation of a suitable information basis and reliable analysis of effects demanded by Meffert/Kirchgeorg (1993, p. 42) are in-avoidable for sustainable development. But this conditions for this information are necessary, but not sufficient. In any case information must not be used within not suitable calculi. Here economists are faced with a real challenge to develop other calculi. The methodologically caused turning away from the interests of future generations is in diametrical contrast to the claims of sustainable development.

All this also refers to a restriction of the environment in its functions to be a reception medium for residues. The load capacity of environment defines the border that must not be exceeded by economic activities and is a guideline for sustainable development (Rat 1994, p 19).

As yet I have concentrated on economic calculi with a long-term orientation (long-term calculi). But short-run calculi may also influence the behaviour of people against the interests of sustainable development.

Within the (short-term orientated) cost accounting the point is, the use of materials and energy, too. The enterprise's outputs of matter and energy results in environmental burden.

If waste streams are linked with costs resulting from the disposal of residues or from paying public fees, for instance for waste water diversion, the managers in enterprises may feel an incentive to reduce or avoid such residues, and this suits sustainable development. Of course incentives will arise if residuals can be exploited and so bring forth some revenues.

But there is no sense in setting off costs of using material and energy from resulting material and energy streams. These matter and energy streams namely didn't cause the costs of material and energy. The parallel often constructed between matter and energy flows on the one side and cost streams on the other side is not a suitable model of reality.

The mixture of technical and economic thoughts represented in this connection is sustained, of course, by the tradition of calculating with full costs, that is shifting all costs step by step to the wanted products of an enterprise. In the interest of sustainable development we must leave these ideas, too (cf. Strebel 2003, p. 158 ff).

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